Simulation

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In the context of computer [→ Algorithm], the primary situation in which the term simulation is used is when the result of the computation of an algorithm produces data that are similar to data produced by a real (non-computerized) system, considered as a reference system. In such case, the original data are measured by sensors, and then compared with the data produced by the computational process. An acceptable difference (evaluated by absolute or relative errors) is defined. When the difference between data are smaller that the acceptable difference, the computational process can be called a simulation of the reference system. The algorithm at hand is then said to be an algorithmic model of the reference system. Hence, one of the major aims of computer simulation is to attempt to model a real-life situation in order to understand how the real system works. By changing variables, predictions may further be made about the behaviour of the system.

Computer (or virtual) simulation is used in many contexts, including the modelling of natural systems or human systems, in order to gain insight into their functioning. Other contexts include simulation of technology for performance optimization, safety engineering, testing, training and education. Simulation can be used to predict the eventual real effects of alternative conditions and courses of action. Key issues in simulation include acquisition of valid source information about the referent, selection of key characteristics and behaviours, use of simplifying approximations and assumptions within the simulation, and fidelity and validity of the simulation results. Such simulation is an objective simulation in the sense that the comparison with the reference system does not depend on human appraisal.

A subtle, but nevertheless significant, difference can be done between computer simulation and other computer processes producing data similar than those acquired or observed in the real world.

Let's take here an example: there are several methods (algorithms) to compute a given sound produced by a given object. They can be classified in two categories:

- Algorithms that aim at modelling the sound itself.

They are based on sound analysis and sound computer synthesis. A typical example here is the Fourier analysis and synthesis. Sound signals are decomposed in Fourier components and can be re synthesized by the inverse method.

- Algorithms that aim at modelling the object that produces the sound.

A typical example is the simulation, of the instrument by means of a physically-based model of that instrument [→ Physically-based modelling].

It is generally accepted in computer sciences, that the word simulation refers to the second approach. Consequently, the word simulation is dedicated to the computation of the cause that produces a given phenomenon, and not to the computation/synthesis of the phenomenon itself. We have here to be aware that the term cause does not address the real cause of the phenomenon, as this real cause is not – or, better, cannot completely be – known. The cause, indeed, corresponds more to a generative system that could play the role of a partial or a plausible cause, than to a hypothetic real cause itself. For recent discussions on that point in physics, one can refer to the concept of Veiled Reality [d'Espagnat, 1995].

In the middle of 60s, research started by the development of computer algorithms dedicated to the synthesis of sensory auditory and visual phenomena. While the request of realism developed, computer algorithms

evolved toward simulation processes. A clear example is the computing of visual appearance of virtual object, that evolved from rendering techniques such as shape or texture mapping to physically-based model of the light-matter interaction. In the same way, in computer animation, physically-based models have been introduced in the beginning of 80s in order to have at disposal more complex and more expressive motions. The trends from synthesis to simulation have been reinforced by the introduction of interactive real time simulation, as implemented in virtual reality systems [→ Virtual reality and virtual environment], and of instrumental simulation [→ Instrumental interaction]. In such uses, differently than in the case of conventional objective simulation discussed before, evaluating the results of the computation process has to be mainly, or at least also, performed through the human senses and action, we can say subjectively.

Two different cases must be distinguished:

1) When a reference system or reference situation exists in the real world, such as a real object having shapes, producing sound, motions, objects manipulated by hands, etc.

In this case, the subjective evaluation led to the notions of perception fidelity, believability and action fidelity [→ Action fidelity]. The simulation is considered successful when the simulacrum resembles with the real phenomena or the real-life reference according to these criteria. The computed algorithm is then said to be an algorithmic model of the reference system, and the whole newly implemented situation is a computer-based representation of the whole real reference situation.

2) When the computer process is not related to any real phenomena, real object, or real life situation, or real task.

In this case, no comparison (either objective nor subjective) is possible and no fidelity criteria can be defined. The subjective appraisal is then related to the acceptance of the computed sensorial data and behaviour, and/or of the new active situation by the human. This acceptance can be the pure sensory appraisals or the possibility to achieve a task. The term of simulation continues to be used, meaning here simulation of a non pre-existing phenomena, object, etc - based on the fact that what is computed is a generic cause able to produce the expected sensory phenomena, rather than the signals representing a phenomenon themselves. The term simulation is here related to the computation of a non-existing but "possibly possible" real object. The extreme case is when any real object cannot exist (either really or possibly), as in the case of very new creative situation. The term still continues to be used, referring to a simulation of a mental imagined object, sensorial phenomenon, situation and task, able to be sensed or acted by humans. In all these creative cases, the evaluation criteria cannot be other than believability, presence, achievement of the task, playability of the simulacrum, intimacy, etc…

References

[d'Espagnat, 1995] B. d'Espagnat. Veiled Reality: An Analysis of Present-Day Quantum Mechanical Concepts. Addison-Wesley, New York, 1995.

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